Centrifuge dewatering and reconstitution of fine coal: a pilot-plant application of the GranuFlow Process

W.W. Wen, R.P. Killmeyer and BX Parekh

Abstract

A continuous pilot-scale test of the GranuFlow Process was conducted using a screen-bowl centrifuge for the dewatering and reconstitution of column-flotation concentrate at a coal preparation plant in Virginia. In this test, a slipstream of the fine clean-coal slurry from the column-flotation concentrate was treated with a bitumen emulsion before dewatering. The treated products from the screen-bowl centrifuge appeared to be dry and in a free-flowing granular form, while the untreated products were wet, sticky and difficult to handle. Test results indicated that the average moisture contents of the dewatered coal products were 35.7%, 35.5%, 32.6%, 29.9% and 26.5% (by weight) with Orimulsion additions of ao%, a7%, 3.2%, 4.8% and 6.4% (by weight), respectively. The handleability and dust reduction of the dewatered coal products were also vastly improved.

Keywords: Dewatering, Slurry, Coal processing, Screenbowl centrifuge

Introduction

The Federal Energy Technology Center (FETC) performed a series of pilot-scale centrifuge dewatering tests at the Powell Mountain Coal Co.'s Mayflower Plant located in St. Charles, VA. The project, which is being conducted under the US Department of Energy's (DOE's) advanced fine-coal dewatering contract (DE-AC22-94PC94155), is being managed by the University of Kentucky Center for Applied Energy Research (UKCAER).

The test series reported here featured the FETC-developed and -patented GranuFlow Process, a concept that combines fine-coal dewatering and reconstitution into one step (Wen and Deurbrouck, 1990; Wen et al., 1995). The process improves fine-coal handleability and reduces the product moisture content. The process minimizes coal losses and dust emissions during transportation, handling and storage. It produces an economically reconstituted fine-clean-coal that is easy to handle. The process requires the addition of small amounts of a specially selected binding material to the fineclean-coal slurry before filtration or centrifugation (Wen et al., 1993; Wen et al. 1995; Wen and Killmeyer, 1996).

This paper summarizes the results of applying the GranuFlow Process to a column flotation clean-coal concentrate in a pilot-plant-scale screen-bowl centrifuge using bitumen emulsion (Orimulsion) as the binder.

Experimental

An Upper Mason seam high-sulfur, 2.01% (by weight), coal was processed at the Mayflower Coal Preparation Plant. The column-flotation slurry concentrate had about 15% (by weight) solids and ı contained 6.5% (by weight) ash. The particle size was 909~ passing 150 mesh (106 gm) with a mean size (d5o) of 25 ~Lm.

The bitumen emulsion used in the study was Orimulsion, a high-Btu bitumen-in-water emulsion from Venezuela. It is being used as a fuel for power generation in several countries. The emulsion contains about 70% (by weight) bitumen, 30% (by weight) water and trace amounts of surfactants. The cost of Orimulsion is about the cost of coal on an equal Btu basis. Domestic asphalt emulsions were tested with less efficiency, particularly at lower temperature (Wen et al., 1993; Wen et al., 1995). FETC! is conducting research on modifying domestic asphalt emulsions so that they could be as effective as Orimulsion.

Centrifuge-dewatering test equipment. The CAER centrifuge-dewatering test circuit at the Mayflower Plant was set up outside the plant and included a 1,900-L (500-gal) slurry feed tank, a 19-L (5-gal) Orimulsion holding container, a gear pump, a 457-mm (18-in.) Decanter screen-bowl centrifuge

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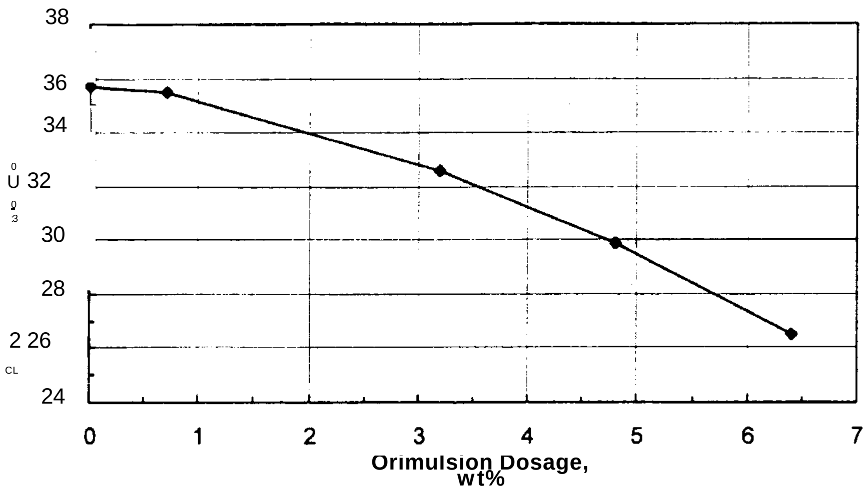

Figure 1 - Centrifuge product moisture contents of the column-flotation concentrate at the Mayflower Coal Preparation Plant: 91% passing 150mesh coal slurry at 15% solids and 6.5% ash (all percentages by weight).

and a product conveyor. The feed tank was set on a platform 9 in (30 ft) above ground, and the centrifuge was set on the ground about 9 in (30 ft) from the feed tank. Slurry was gravity fed to the centrifuge via a 50.8-mm (2-in.) pipe connected from the tank to the centrifuge. A tube valve located about 0.9-in (3-ft) from the centrifuge feed inlet was used to control the feed rate. Orimulsion was pumped directly into the slurry feed line about 0.3 in (I ft) away from the bottom of the feed tank, providing about 8.5 in (28 ft) of inline mixing distance.

The capacity of the centrifuge was around 0.9 to 1.8 t/h (I to 2 stph) of coal, and the rotation speed was at 1,000 rpm, which provided a force field of 226g. The screen opening was about 28 mesh (500 lam).

Test procedure. The slurry feed rate to the centrifuge was kept constant at about 76 Umin (20 gpm), which provided about 0.68 t1h (0.75 stph) of coal. The dewatering tests started without Ofimulsion addition to obtain the baseline data for the screen-bowl centrifuge dewatering. At the end of 30 min of baseline operation, the Orimulsion pump was turned on. Generally, samples of the slurry feed, dewatered product coal, and main and screen effluents were collected at 10 and 20 min of operation for each test condition. Timed samples at a predetermined time were usually taken after 20 min-of operation for material balance determination. At the end of every test condition, the Orimulsion pump setting was changed. Samples were analyzed for product moisture, solids and ash contents, and product dust index.

Results and discussion

Effect of Orimullsion concentration on product moisture and handleabflity. Test results shown in Fig. I indicate that the average moisture contents of the dewatered coal were 35.7%, 35.5%, 32.6%, 29.9% and 26.5% (by weight) with Orimulsion additions of 0.0%, 0.7%, 3.2%, 4.8% and 6.4% (by weight), respectively. The handleability of the centrifuge product was greatly improved with the addition of Orimulsion. Free-flowing granules, as opposed to wet lumpy material, were clearly observed with Orimulsion additions at or above 3.2% (by weight).

The improved handleability of the product was also indicated by the formation of product piles discharged from the conveyor. During the tests, two product coal piles formed under the conveyor. The primary discharge pile was formed at the very end of the conveyor belt due to freefailing coal-granules. The second discharge pile was formed under a conveyor scraper, which was located about 300 min (12 in.) underneath the end of conveyor belt.

The Orimulsion-treated primary-discharge pile showed a much smaller angle of repose than the untreated primary discharge coal pile. The angle of repose is the angle between the horizontal and the slope of a heap of material dropped from some elevation. The smaller the angle of repose, the more flowable is the material. Also, most of the Orimulsion-treated coal ended up in the primary discharge pile, while most of the untreated coal ended in the secondary discharged pile, indicating that the untreated coal was sticking to the conveyor belt.

Effect of Orimulsion concentration on product dust index. To evaluate the performance of the GranuFlow Process for dust control, FETC adopted a simple Ro-Tap dryscreening process to experimentally measure the dust index *(Ij)* of the cakes with a constant amount of stress applied. A dust-reduction efficiency (E) is calculated based on the following equation

I -L
E = ~0 ~' x 100
1"

E is the dust reduction efficiency of dry cake (%);

1,, is the dust index of coal, which is the cumulative weight percent of feed coal finer than 150 mesh (106 lim) by wet screening; and

ii is the dust index of cake, which is the cumulative weight percent of dry cake finer than 150 mesh (106 pin) after Ro-Tapping for 5 min.

The dust index of the feed coal (10) was 9 1 % (by weight) passing 150 mesh (106 lam). This value was obtained from a wet-screen analysis. The average dust indices of the Orimulsion-treated dry product *Qj*) were 82%, 56%, 12%, 5% and 2% (by weight) using Orimulsion dosages of 0.0%, 0.7%, 3.2%,4.8% and 6.4% (by weight), respectively. Dustreduction efficiency, as shown in Table 1, indicated that more than 85 % (by weight) of the dust (i.e., material finer than 150 mesh) was reduced by agglomeration at 3.2% (by weight) Orimulsion. The dust-reduction efficiencies reached 95% and 98% with 4.8% and 6.4% (by weight) Orimulsion additions, respectively.

Effect of Orimulsion treatment on product recovery, product ash and effluent solids reductions. The Orimulsion treatments dramatically reduced the solids content in both the screen and main effluents. As a result, the dewatered coal recovery, as shown in Table 2, increased about 45%, from 64.7% to 94. 1 % (by weight), at Orimulsion dosages of 0.0% and 6.4% (by weight), respectively.

The solids reduction in the main effluent alone accounted for about a 17.5% (by weight) increase in the dewatered

Table 1 - GranuFlow Process testing results on column flotation concentrate from the Mayflower plant: at 75.6 Umin (20 gpm) feed rate, 15% slurry solids, 91% -150 mesh and 6.5% ash in slurry solids (all percentages by weight).

Test No.	Orimulsion, %	Product moisture, %	Product ash, %	Main effluent solids, %	Main effluent ash, %	Screen effluent solids, %	Screen effluent ash, %	Dust index, %	Reduction efficiency, %
MF 1-1	0.0	35.7	4.4	3.4	14.0	44.7	9.3	82	10
MF 1-2	0.7	35.5	4.4	3.0	16.1	33.7	9.3	56	38
MF 1-3	3.2	32.8	4.4	2.8	17.5	9.6	11.3	14	85
MF 1-4	4.8	28.3	4.3	1.1	31.8	1.5	16.9	3	97
MF 1-5	6.4	26.5	4.4	NA*	NA*	3.1	11.8	2	98
MF 1-6	4.8	31.4	4.4	2.5	16.8	3.3	13.2	7	92
MF 1-7	3.2	32.4	4.5	3.3	16.9	8.5	11.1	9	90

*No sample

product at the Orimulsion dosage of 6.4% (by weight).

The benefit of this effluent solids reduction is threefold:

increased product recovery by 45% (by weight), reduced polymer dosage in the waste slurry thickener and extended lifetime of the slurry impoundment.

Table I shows the product ash contents and shows the effluent ash and solids contents. It is interesting to note that the average screen-bowl product ash content was 4.4% (by weight), which was much lower than the flotation product ash content of 6.5% (by weight). Evidently, centrifuge dewatering provided some additional ash reduction. The results also indicated that the bitumen in the Orimulsion selectively agglomerated coal particles but not ash-forming particles, resulting in an increase in the effluent solids ash content and product recovery.

Table 2 - Approximate solids material balance for centrifuge products from the column-f lotation concentrate from the Mayflower plant: 457-mm (1 8-in.) centrifuge at 1,000 rpm and 226 g-force)

Test No.	Orimulsion wt%	Solids balance, wt*/6 Feed	Product	Main effluent	Screen effluent
IVIF 1-1	0.0	100	64.7	22.5	12.8
IVIF 1-2	0.7	100	73.1	18.0	8.9
MF 1-3	3.2	100	82.2	15.3	2.5
MF 1-4	4.8	100	93.5	6.1	0.4
MF 1-5	6.4	100	94.1	5.0*	0.9
MF 1-6	4.8	100	86.7	12.4	0.9
MF 1-7	3.2	100	83.5	14.1	2.4

*This data was calculated by using 1.1% (by weight) of the main effluent solids from MF 1-4.

Potential benefits in commercial applications. The process has a variety of potential benefits, some of which may be more important than others, depending on the particular application. Some commercial benefits are as follows:

increased amounts of fine coal can be added to utility plant feedstocks without creating handling problems, the top size of the coal fed to a preparation plant can be reduced to take advantage of increased liberation to improve the quality of the clean-coal product,

coal fines (valuable fuel) can be reclaimed from waste ponds with attendant cleanup of waste sites and

handleability during transportation can be improved by alleviating dust and freezing problems.

Cost estimation. The cost of Orimulsion at a seaport in the southeastern United States is around $44/t ($40/st). When using a bitumen dosage of around 6% (by weight), which is equivalent to an Orimulsion dosage of 8.6% (by weight), this would add $3.79/t ($3.44/st) of fine-coal product treated. Approximately half of the cost of Orimulsion can be credited as additional salabig Btus at the price of coal of $27.50/t ($25.00/st). Thus, the true cost may be $2.20/t ($2.00/st) of fine coal. If this treated fine coal is about 10% to 20% (by weight) of the coal shipment sold to a utility, the actual added cost of shipped coal is around $0.22 to $0.44/t ($0.20 to $0.40/st). This cost estimation does not include the transportation cost of Orimulsion to the preparation plant, which could be significant depending on location. The major cost savings from using a bitumen emulsion such as Orimulsion could come from:

- higher recovery of fine coal product, less wind loss during transportation, longer lifetimes for waste impoundments, the elimination of thermal drying, less need for dust suppressants or freeze conditioning agents (Wen et al., 1995; Wen and Killmeyer, 1996), more salable and acceptable fine clean-coal product and the recovery of fine coal that is now being disposed of.

Conclusions

The GranuFlow Process was effective in the dewatering of ultraftne clean coal using a screen-bowl centrifuge. The process in general improved clean-coal handleability, solids recovery, moisture content and dustiness of the final product. The process also reduced the amount of solids lost in the main and screen bowl effluents by about 30% (by weight).

The addition of about 6.4% (by weight) of Orimulsion to the clean-coal slurry lowered the moisture content of the final product from 35.7% to 26.5 % (by weight) and improved coal recovery from 64.7% to 94.1% (by weight).

The addition of 4.8% (by weight) Orimulsion reduced the centrifuge main effluent solids from 3.4% to 1. 1% (by weight). Similarly, the screen effluent solids was reduced from 44.7% to 1.5% (by weight).

In general, the dewatering results obtained with the 457-mm- (18-in.-) diarn pilot-scale centrifuge were much better than those obtained with a smaller 152mm- (6-in.-) diam laboratory unit.

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